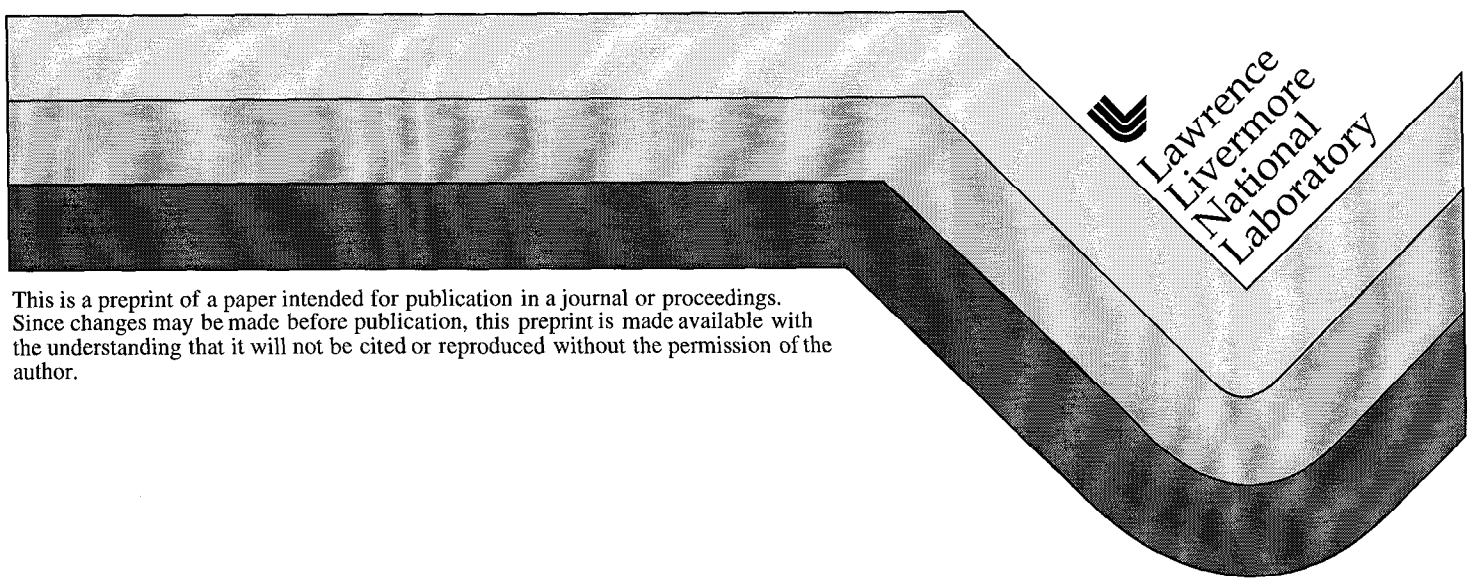
UCRL-JC-134884
PREPRINT

Uncertainty in Dispersion Forecasts Using Meteorological Ensembles

M.J. Leach
H-N. Chin

This paper was prepared for submittal to the
Chem Bio Non-Proliferation Program Annual Meeting
Washington, DC
July 22, 1999

July 12, 1999



This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.

DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

Uncertainty in Dispersion Forecasts using Meteorological Ensembles

Presented by: Martin J. Leach, Lawrence Livermore National Laboratory
925-422-5192, e-mail:mleach@llnl.gov

Co-investigator: Hung-Neng (Steve) Chin, Lawrence Livermore National Laboratory

Objectives: The usefulness of dispersion forecasts depends on proper interpretation of results. Understanding the uncertainty in model predictions and the range of possible outcomes is critical for determining the optimal course of action in response to terrorist attacks. One of the objectives for the Modeling and Prediction initiative is creating tools for emergency planning for special events such as the upcoming the Olympics. Meteorological forecasts hours to days in advance are used to estimate the dispersion at the time of the event. However, there is uncertainty in any meteorological forecast, arising from both errors in the data (both initial conditions and boundary conditions) and from errors in the model. We use ensemble forecasts to estimate the uncertainty in the forecasts and the range of possible outcomes.

Recent Progress: An approach for quantifying meteorological uncertainty is via development of an ensemble of forecasts from slightly perturbed initial conditions (Sivillo et al., 1997) to predict the time evolution of the probability density function of atmospheric variables (Mullen and Baumhefner, 1994). We create an ensemble of forecasts by varying the initial (and boundary) conditions for the COAMPS meteorological model. The variations in the initial conditions must be consistent with analysis error. Optimally, the range of initial conditions would encompass the "true" atmospheric state, but which is never actually known. Our method for creating varying initial conditions is to use different global data sets to derive the necessary data. We use two models from the National Weather Service (the AVN and ETA models) and one from the Navy (the NOGAPS model). In addition to those data sets we perturb the data from those models, using a normally distributed random number at each grid point in the COAMPS model. We perturb the (u,v) wind components, the temperature and the moisture. The size of the perturbation is determined by the variability within that variable field. The forecasts are run for 48 hours. We then use the output from the COAMPS model to drive a Lagrangian dispersion model (LODI) for simulated releases. The results from a simulated release from hour 33 are shown in Figure 1. The center of the domain is Oakland airport and the basic on-shore wind is from the southwest. In three of the simulations, the plume goes over the top of the hills to the northeast, and in the other three the plume hugs the coastline and goes around those hills The two solutions reflect a dependence on the Froude number, a ratio of the Kinetic energy to Potential energy. Higher Kinetic energy flow (Higher Froude number) flow goes over the top of the

mountain, while lower Kinetic energy flow goes around the hills.

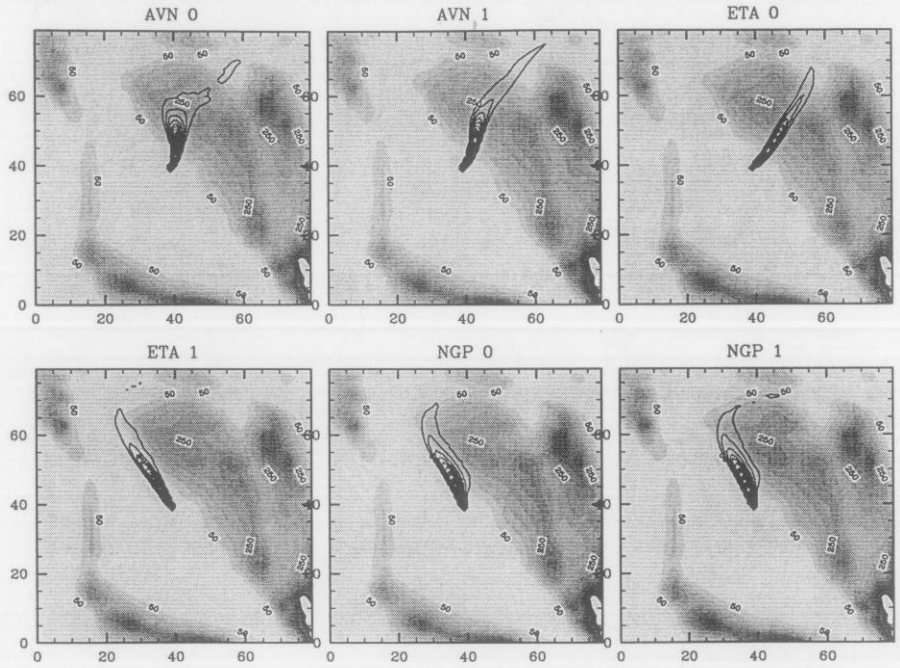


Figure 1. The six COAMPS simulations included in the ensemble. The simulations are labeled with the large-scale model used to create the initial conditions, without (labeled 0) and with (labeled 1) perturbations. The concentrations are contoured, the topography is represented by the grey-scale.

Future Outlook: We will continue to perform ensemble forecasts, using means and differences of the global data sets to create initial conditions. We expect to create ensembles with up to 20 individual forecasts. Using our forecast system to demonstrate the value of ensemble forecasts to estimate uncertainty in dispersion forecasts we will make forecasts in a prototype real situation, such as the Olympics Games to be held in Salt Lake City and the surrounding area.

We also plan to use ensemble methods to study uncertainty due to the the range of possible model parameters and stochastic fluctuations stemming from the turbulent nature of the atmosphere (Lewellen and Sykes, 1989), with particular emphasis on the sensitivity to urban-canopy parameters.

References:

Lewellen , W.S. and R.I. Sykes, 1989: Meteorological Data Needs for Modeling Air Quality Uncertainties, *J. Amos. And Ocean. Tech.* **6**, 759-767

Mullen, S.L. and D.P. Baumhefner, 1994: Monte Carlo simulations of explosive cyclogenesis. *Mo. Wea. Rev.*,**122,**1548-1567.

Sivillo, J.K. J.E. Ahlquistm Z. Toth, 1997: An Ensemble Forecasting Primer, *Wea. And Forecast.*12,809-818.

*This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.